Computerizing Test Schedules in a Hospital
Its Necessity and Importance

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I. Introduction

Whenever the demand of a service provider surpasses the offer, there is a need to implement a scheduling system in order to better assist all the requests made. Therefore, the existence of a quick, just and optimised system of scheduling is of vital importance for the management of those who render this service. This type of system should provide the consumer, who will have to wait until his problem will be taken care of, with concrete information in due time, as well as be efficient in its service.

This service to be provided greatens in importance when referring to the health subsystem, since the patients are, usually, in poor physical and psychological condition. In a large hospital, like Coimbra University Hospital (CUH), the scheduling system of radiological tests is still influenced by other decisive factors, such as the quantity and variety of information to be processed. This system is perfectly integrated in the radiology information system (SIIM – Sistema Informático de Imagiologia) at CUH, which is the system responsible for all the appointments and administrative tasks of the radiology sector.

For instance, a test can be scheduled for a later date because it calls for some previous preparation on behalf of the patient. However, in most cases, tests are scheduled for a later date due to the lack of openings in the short term and a great number of requests for appointments. In fact, certain kinds of tests are even scheduled more than a year in advance.

II. Scheduling in a Large Hospital

Scheduling in such a large hospital is not an easy task. The radiology department at CUH has an annual production of approximately 180,000 tests and dozens of medical specialists. It is one of the largest departments in the hospital because almost every patient needs, at least one radiological test. In order to better serve these patients the radiology department is presently distributed on three floors and seven subspecialties (technical units) where these tests are performed. Quite often these technical units are prepared and optimised for specific techniques or modalities to be performed by specialists. Each modality unit may have several rooms where examination takes place. Each technical unit has several appointment schedules (one for each modality unit), which makes the need for a computerized system at the administrative level a top priority (Figure 1).

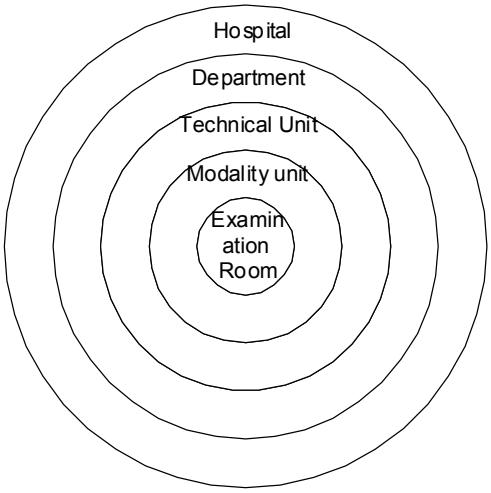

Figure 1: Several divisions in a hospital.

A request form must be filled out when a patient needs a radiology test. This form must meet certain requirements. To better understand the way the scheduling is processed it is necessary to describe some of these.

When an appointment system is introduced, one of the most important tasks is to define an appointment schedule indicating how many patients (or tests) can be expected or treated in a certain period of time. Each division (time slot) refers to one test instead of referring to

one patient, because at CUH each patient may have several related tests scheduled on the same day in the same form. This is a system based on a fixed duration of examinations. With the individual appointment schedule, one appointment per unit of time is made. The system reduces the waiting time for patients and allows them to arrive closer to the time they will be seen. The aim is to make one appointment per unit of time causing the waiting time of the patients to be reduced to a minimum, instead of calling all the patients in the beginning of the day. However this may be disadvantageous for the hospital, because the patient may arrive late, or the previous test may take less time than expected to be preformed. In each case the service stops because of lack of patients. It is best to tell the patient to arrive early, or call several at the same time. This kind of block appointments is best suited if the average time that a physician spends with each patient is small. Another solution is combining the other two. The time slots are made exponentially larger during the day and patients are called at their schedule time (Figure 2). In this solution there are always patients waiting for tests and the waiting time is minimized.

Schedule book		Duration
9:00	Test	0:30
9:30	Test	0:30
10:00		0:30
10:30	Test	0:30
11:00		0:30
11:30		0:30
12:00	Test	0:30
12:30	Test	0:30
13:00		

Schedule book		Duration
9:00	Test	0:03
9:03	Test	0:12
9:15		0:18
9:33	Test	0:27
10:00		0:33
10:33		0:42
11:15	Test	0:48
12:03	Test	0:57
13:00		

Figure 2: Constant and variable time slots duration.

III. SCHEDULING CONSTRAINTS

To achieve a better scheduling some data must be provided to the administrative. The patient's hospital number, requesting department, origin of the patient (outpatients, inpatients and external patients) and responsible health subsystem are important information that always needs to be present in the request form. Other information refers only to the specific state of the patient, like pregnancy, previous operations or need for transportation. Each request form may have several tests on it, but they must share the same modality. They must belong to the same scheduling book. Usually these tests need to be preformed one after the other.

In accordance with recommendations made by the Health Ministry, patients may come from a wide range of situations and origins and there must be procedures to ensure equality of opportunities for everyone. In order to accomplish this, the appointment schedules should allow for a number of vacancies for hospitalisation, outpatient, external consultations and other situations. On the other hand there are situations, which lead to different levels of urgency that must be taken into consideration when preparing the scheduling books so not to overload them. Because of the lack of space and need of its optimisations, the rooms in the technical units may not be used in the same way in the morning and in the afternoon (Figure 3).

Schedule book					
Morning			Afternoon		
9:00	Test	Outpatient	14:00	Test	Outpatient
9:30	Test	Internal	14:30	Test	Outpatient
10:00			15:00	Test	Internal
10:30	Test	Outpatient	15:30		
11:00			16:00	Test	Outpatient
11:30			16:30	Test	Internal
12:00	Test	Internal	17:00	Test	Internal
12:30	Test	Internal	17:30	Test	Internal
13:00			18:00		

Figure 3: Schedule book example.

They may belong to different modality units during the day and during the week. Therefore the schedule book of one day is segmented in order to take into account all the constraints. It is split into a morning and an afternoon schedule. Each one is then subdivided by the number of tests that may be performed to obtain the scheduling time slots.

The definition or specification of all these conditions for the computer program leads to the design of a computer screen similar to a page in an appointment

diary. For the administrative this approach makes the transition from a manual scheduling system to a computer based scheduling system easier.

IV. Automatic versus manual

A completely automatic system may not overcome all the situations that may occur. There are always some cases that need to be handled with special care and urgent scheduling and overbooking situations must be met. An alternative for a decentralized on-line system for appointment administration is one that works semi-automatically; appointments are assigned by hand, but based on the information about the vacancies the computer shows. In some cases it may be made without any help from the computer: This is the manual solution. This may be the case of overbooking an urgent test, for instance. The administrative operator knows that it must be done even if the schedule book is full.

The best solution depends on the hospital and should take into account factors such as the amount of patients and tests, technical units, modality units, scheduling constraints and infrastructures. Because of the large volume of information to be processed and the variety of cases that may appear to the operator in the CUH the appointment scheduling should be made using the three forms.

V. Rescheduling

Related to the scheduling system is also the rescheduling system. Rescheduling hundreds of tests may occur in a single day, for example when there is a medical conference or a strike. One of the biggest problems related to rescheduling tests, is that they can be rescheduled at a much later date than originally scheduled. Therefore, it is necessary to find alternative ways that allow these tests to be evenly spaced out in time in order to minimize the patients' losses. Usually a controlled overbooking is allowed in this situation. However long waiting lists may not be completely avoided and cause long delays, and in some cases patients are required to confirm their appointments. And if this confirmation is not made, this opening can be considered unfilled and given to another patient. After rescheduling a test, the patient should be notified. With automated procedures the administrative operator can group the tests with similar constraints and reschedule them at once. The program computes the new test dates and inserts them automatically in the schedule book. Then prints out the mailing letters to be sent to the patients indicating the reason of the reschedule, the previous date and the updated test date.

VI. Implementation considerations

To implement such a scheduling system the following are needed: a scheduling table with date and time, tests, etc. and a calendar table with weekdays, fixed and variable holidays, and maintenance days for the equipment. The calendar table may be calculated online or in advance. There are several ways to implement the scheduling subsystem:

- One way is to start with an empty schedule table in order to add each time slot when it is needed. Every time a test is to be scheduled it is virtually constructed taking into account all the parameters and constraints of the technical units, the modality units, test characteristics and calendar. Then the first time slot available in the virtual table is chosen. This is a very time consuming procedure. This kind of procedure may be better suitable for small departments with lots of changes in the schedule book.
- Another way is to start with a pre-made schedule table with all the time slots for a certain period (e.g. a year). To achieve this the schedule table is constructed beforehand taking into account all the parameters and constraints of the technical units, the modality units, test characteristics and calendar. Although this is a time consuming procedure, it only has to be calculated once. When there is a

need to schedule a test the first time slot available in that schedule table is used (Figure 4).

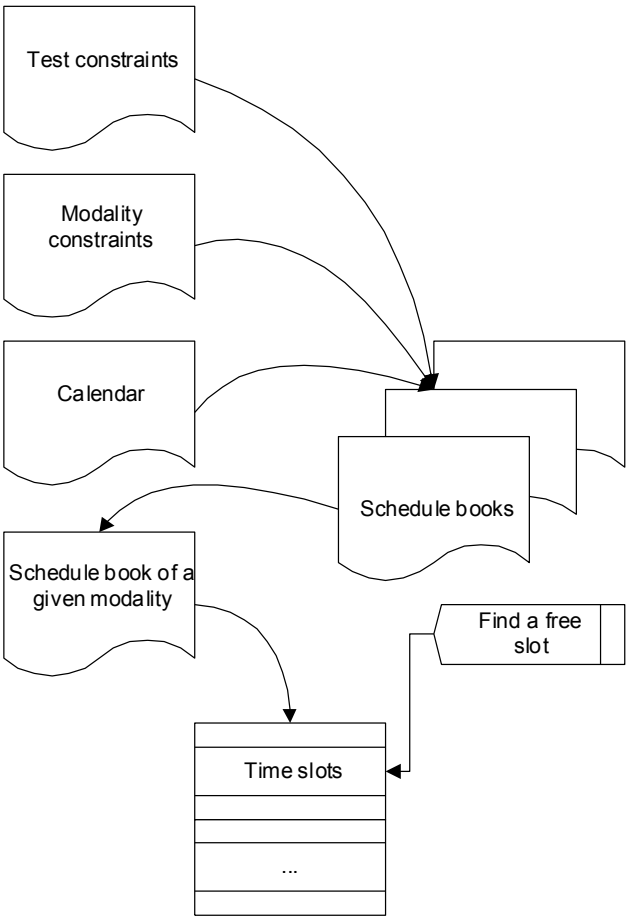

Figure 4: How it works.

This procedure is much quicker than the latter and was chosen for the SIIM program used in CUH. Having the test tables with all the constraints defined, the calendar table must be calculated, and then the schedule table is computed. Because the CUH is a university hospital often new doctors come and go into the radiology department. Procedures have also been made to allow the change of the parameters after the schedule table is computed. Calculating this new schedule table, tests should be left in the old time slots, but they may also be rescheduled. Usually the empty time slots are the ones that should change in order to minimize patients' losses.

VII. Conclusion

The computerization and automation of all these procedures of scheduling and rescheduling involves of a number of questions that are raised from coding routines to its use by the administrative and approval by the doctors and department managers.

There are enormous advantages of using a computer-based system. Decentralization can be used with great success, reducing the need for a patient to move from point to point in a large hospital. Rescheduling a group of appointments or cancelling an appointment hour can be made easily, with automatic generation of mail advisers and messages to all patients with names and addresses and doesn't involve a lot of search work. Statistical information can easily be inferred from the recorded data instead of intensive efforts. This can be done more often and more direct to the problem being analysed. Many mistakes that used to appear to be made in the field of identification of patients are reduced. Lots of information needs only be introduced once.

The aim is not only to free the users workload, but also to allow them to perform more tasks quicker and with less stress, that is, more efficiently. For the service manager, the combined information that he is able to retrieve and relate to will become a valuable aide in the optimisation of resources.

VIII. Acknowledgements

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